

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
5 February 2004 (05.02.2004)

PCT

(10) International Publication Number
WO 2004/012287 A3

- (51) International Patent Classification⁷: **H01M 8/02**, 8/12
- (21) International Application Number:
PCT/CA2003/001118
- (22) International Filing Date: 24 July 2003 (24.07.2003)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
10/207,668 25 July 2002 (25.07.2002) US
- (71) Applicant (for all designated States except US): **ALBERTA RESEARCH COUNCIL INC.** [CA/CA]; 250 Karl Clark Road, Edmonton, Alberta T6N 1E4 (CA).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **SARKAR, Partho** [CA/CA]; #34 - 3221 - 119th Street, Edmonton, Alberta T6J 5K7 (CA). **RHO, Hongsang** [CA/CA]; 11004 - 11th

Avenue NW, Edmonton, Alberta T6J 6M8 (CA). **JOHANSON, Lorne** [CA/CA]; 11324 - 111A Avenue, Edmonton, Alberta T5G 0E8 (CA). **YAMARTE, Luis** [CA/CA]; 10655 - 66th Ave. NW, Edmonton, Alberta T6H 1X5 (CA).

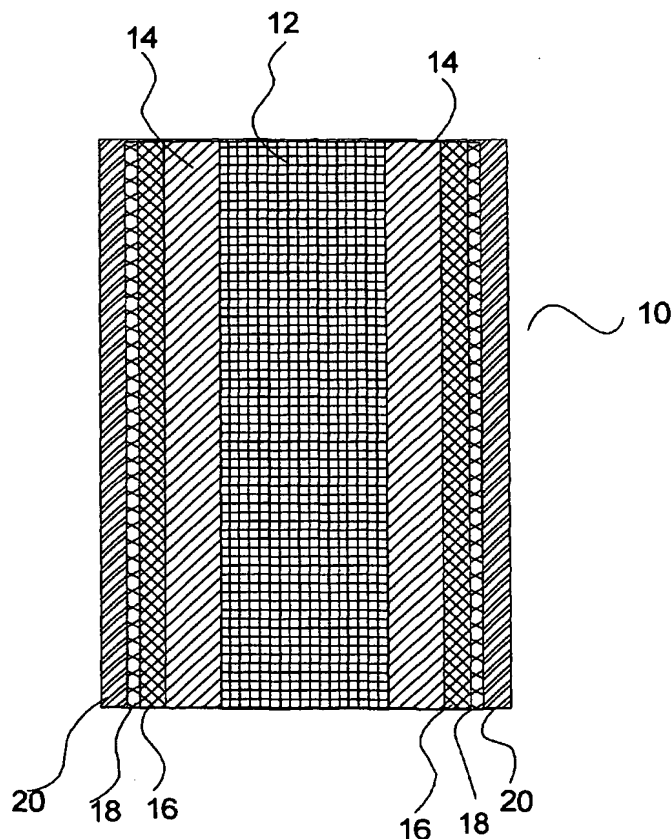
(74) Agent: **LEE, Brian**; c/o Gowling Lafleur Henderson LLP, 2300-1055 Dunsmuir Street, PO Box 49122, Vancouver, British Columbia V7X 1J1 (CA).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),

[Continued on next page]

(54) Title: METAL-SUPPORTED TUBULAR FUEL CELL



(57) Abstract: This invention relates to a method of manufacturing a metal-supported tubular micro-solid oxide fuel cell, and a fuel cell made from such method. The method comprises the steps of coating a wooden substrate member with a conductive substrate layer, coating the substrate layer with an inner electrode layer, coating the inner electrode layer with an electrolyte layer, drying and sintering the coated substrate member such that the substrate member combusts, coating the electrolyte layer with an outer electrode layer, and then drying and sintering the layers. The invention further relates to a method of manufacturing a tubular solid oxide fuel cell assembly comprising: a) coating a tubular substantially metallic support layer with a ceramic or cermet inner electrode layer, b) coating the inner electrode layer with a ceramic electrolyte layer; c) coating the electrolyte layer with a ceramic or cermet outer electrode layer, then d) sintering the layers to produce a hollow tubular metal-supported fuel cell; the electrode and electrolyte layers having a collective wall thickness of 80 μm or less, the support layer having sufficient mechanical strength to support the electrode and electrolyte layers and sufficient porosity to flow a reactant therethrough.



Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE,
ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO,
SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM,
GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

(88) Date of publication of the international search report:

1 July 2004

Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/CA 03/01118

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01M8/02 H01M8/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01/09968 A (UNIV CALIFORNIA ;VISCO STEVEN J (US); DEJONGHE LUTGARD C (US); JAC) 8 February 2001 (2001-02-08) page 11, lines 1-34; page 14, lines 15-22; page 19, lines 14-17; Figure 5D ---	1,13,17
Y	US 6 080 501 A (DAVIS JAMES L ET AL) 27 June 2000 (2000-06-27) column 2, line 61 -column 2, line 67 column 3, line 10 -column 3, line 62 ---	1,13,17
Y	WO 01/86030 A (ALBERTA RES COUNCIL INC ;SARKAR PARTHO (CA)) 15 November 2001 (2001-11-15) page 16, line 14 - line 37 claim 17 ---	1,13,17
X	---	24
	-/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- * & * document member of the same patent family

Date of the actual completion of the international search

20 Apr11 2004

Date of mailing of the international search report

29.04.04

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Schwaller, J-M

INTERNATIONAL SEARCH REPORT

International Application No

PCT/CA 03/01118

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	WO 03/069705 A (ALBERTA RES COUNCIL INC ;SARKAR PARTHO (CA); RHO HONGSANG (CA)) 21 August 2003 (2003-08-21) page 16, line 14 -page 17, line 25; claims 12,13 ---	24-36
E	WO 03/062503 A (ALBERTA RES COUNCIL INC ;SARKAR PARTHO (CA); RHO HONGSANG (CA)) 31 July 2003 (2003-07-31) page 19, line 30 -page 20, line 29; claims 20,29,32 -----	24-36

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA 03/01118

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this International application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-23

Tubular solid oxide fuel cell assembly comprising:

- a tubular metallic porous support having sufficient porosity and strength to allow a reactant flow therethrough
 - a tubular layer assembly having a thickness of 80 microns or less and being supported thereon, this layer comprising concentrically
 - i) a ceramic or cermet inner electrode layer
 - ii) a ceramic middle electrolyte layer
 - iii) a ceramic or cermet outer electrode layer
- and method for producing such an assembly

2. Claims: 24-36

Method for producing a tubular oxide fuel cell comprising:

- coating a combustible non-conductive substrate with a conductive layer
- coating said conductive layer with an inner electrode layer by electrophoretic deposition
- coating the inner electrode layer with an electrolyte layer
- coating said electrolyte layer with an outer electrode layer
- drying and sintering the layers such that the combustible substrate combusts to leave a tubular fuel cell

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/CA 03/01118

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 0109968	A	08-02-2001	US 6605316 B1	12-08-2003
			AU 6616200 A	19-02-2001
			EP 1228546 A1	07-08-2002
			WO 0109968 A1	08-02-2001
			US 2003021900 A1	30-01-2003
			US 2003059668 A1	27-03-2003
<hr/>				
US 6080501	A	27-06-2000	NONE	
<hr/>				
WO 0186030	A	15-11-2001	CA 2308092 A1	10-11-2001
			AU 5997001 A	20-11-2001
			WO 0186030 A1	15-11-2001
			EP 1194615 A1	10-04-2002
			JP 2003532609 T	05-11-2003
			US 2003178307 A1	25-09-2003
			US 6607645 B1	19-08-2003
<hr/>				
WO 03069705	A	21-08-2003	US 2003134169 A1	17-07-2003
			WO 03069705 A2	21-08-2003
			US 2003134170 A1	17-07-2003
			US 2003134171 A1	17-07-2003
<hr/>				
WO 03062503	A	31-07-2003	US 2003134176 A1	17-07-2003
			WO 03062503 A1	31-07-2003
			US 2003134169 A1	17-07-2003
			US 2003134170 A1	17-07-2003
			US 2003134171 A1	17-07-2003
<hr/>				